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# Linear and nonlinear plasmonics from isotropic and anisotropic integrated nanocomposites for quantum information applications.

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***Objective***

<u>General objective</u>: Showing that our integrated plasmonic nanocomposites are candidates for new ultrafast quantum information nanodevices.

<u>Particular objectives</u>: Showing that they are (enhanced) sources of individual photons.

**Scientific Report**

**a) <u>Passivation effects and enhanced hydrogen diffusion</u>:** By varying the ion (Au or Ag) and its fluence when irradiating a system of silicon nanocrystals (Si-NCs) embedded in silica at high depth inside the matrix (1-2 μm), a noticeable increase of the amount of hydrogen, or nitrogen, that diffuses into the silica matrix is achieved. As a consequence, a much better passivation of defects of the Si-NCs is obtained, allowing also a large increment of the photoluminescence quantum efficiency and of the number of Si-NCs optically active of this system.

i) Journal of Nanotechnology 2013, 736478 (2013). http://dx.doi.org/10.1155/2013/736478
ii) Journal of Nanotechnology, in revision.

**b) <u>PL modification by plasmonic, surface and porosity roles</u>:** Colloidal Au nanoparticles (NPs) were added to luminescent porous silicon by drop casting. These NPs interact with this system by modifying its optical properties such as photoluminescence. The mechanisms by which occurs this modification would be the porosity of the silicon matrix, the effects of the surface chemical modification and the role played by the plasmonic effects of the metallic Au NPs. Although these mechanisms compete between themselves, it is evident that controlling the porosity would be the main asset to obtain the best effects on PL from the plasmonic phenomenon and the surface chemical modification.

i) Journal of Photoluminescence, in press. http://dx.doi.org/10.1016/j.jlumin.2013.09.053

**c) <u>Effects of size and shape on NLO response by Au NPs in sapphire</u>:** Nonlinear optical response of Au metallic NPs, synthesized and embedded in sapphire by using ion implantation, as a function of their size and shape were studied. The size of the Au NPs was varied by controlling the annealing time of the gold-irradiated sapphire in a reducing atmosphere. Their shape was changed from approximately spherical to prolate by swift heavy-ion irradiation using $Si^{3+}$, obtaining an anisotropic composite consisting in deformed

NPs, all oriented in the direction of the Si beam irradiation. At 532 nm and 26 ps pulses, the isotropic system shows negative nonlinear absorption increasing with size, and size independent positive nonlinear refraction. On the other hand, prolate nanoparticles show negative (null) absorption and null (positive) refraction for the minor (major) axis. This kind of system also shows figures of merit and relaxing times in the order of the picoseconds, appropriate for all-optical switching applications.
i) Optical Material Express, in press.

It still remains to be studied the statistics of the emitted photons by these combined systems. A Hanbury-Brown interferometer is in course of validation (using typical BBO crystals). Since this is the graduation work of one of my students, the validation and the measurement of the corresponding statistics should be finished as for March of the next year.